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SUMMARY

Eight male right-handed subjects performed a total of twelve 3-minute runs on a compensatory tracking task. The subjects were divided into two groups matched for handedness. One group performed the first six runs with the preferred (right) hand whilst the other group used the non-preferred (left) hand. For the remaining six runs the two groups used their other hand.

No significant differences were found between performance with the two hands. Performance with the hand utilized in the second half of the experiment was significantly better than that used in the first half. The results of the experiment are further examined in terms of the learning phenomena normally associated with the acquisition of psychomotor skills. The absence of both unilateral and bilateral reminiscence effects are discussed.

Departmental Reference: HFG 117

CONTENTS

1 INTRODUCTION

The main question that this report will attempt to answer is whether a person can perform a tracking task equally well with his preferred and non-preferred hand. The lack of recent literature specifically relating the two topics of handedness and tracking performance (despite the volumes of literature on each) can be attributed to the fact that the question might appear to have been answered at an early date. However, a review of the literature indicates a number of hypotheses that can be tested experimentally.

The term 'tracking' embraces a wide variety of psychomotor tasks. The place of mirror-tracing in this category is not clear but for the record, and since it preceeds the work on conventional tracking tasks, the work performed on handedness and mirror drawing will be briefly considered. Ross[1] showed that the non-dominant hand was superior to the dominant on the first five trials, while the dominant hand was superior on the last three trials. Although primarily concerned with transfer effects, eg pro-active inhibition and practice, the results do indicate that the non-dominant hand is, at least, not vastly inferior to the dominant. The work of Simon[2] in the same journal bears out these results.

A more recent study, Johnson and Michels[3] stresses the importance of the first trial on the outcome of the results obtained in experiments of this nature, after which he concludes "it matters little which hand is being used". Summarizing the above then, it would appear that for mirror-tracing tasks the dominant hand is certainly not very much superior to the non-dominant, if at all.

As previously mentioned, the value of mirror-tracing experiments with respect to what is now usually meant by the term 'tracking' is questionable. The remainder of the work is more directly relevant to the tracking task that this present experiment used.

Simon, De Crow, Lincoln and Smith[4] investigated tracking accuracy of both direct and aided tracking for both the preferred and non-preferred hand in right and left trained individuals. No significant differences were found. The apparatus employed was a hand wheel control and the tracking was unidimensional and they themselves suggest that "it appears to differ from certain other psychomotor skills in that neither handedness nor usage significantly affects accuracy".

The results of this experiment seem, therefore, to indicate that the questions asked at the beginning of the Introduction may have to be asked for each specific situation encountered.

Grant and Kaestner[5] investigated the effect of handedness, target direction and target speed in a uni-dimensional tracking task. They found that: "neither handedness nor target direction contributed to the significant variation in the experiment, but they had a combined effect or interaction that was statistically significant".

Clearly, this experiment supports the implications concerning the specific nature of the individual tracking task and reinforces the view that it may not be possible for one to generalise too freely from the results of prior experimentation.

Provins[6] studied handedness in relation to tasks of varying complexity, the three tasks he used were:-

1. Flexor contraction of the index finger in the reproduction of pressures.
2. Speed of tapping.
3. Aiming.

According to Provins, the results he obtained indicated that the difference in performance between the two hands occur only when timing or serial organisation of muscle activity is required and that such differences may be due to training. The value of this work lies in its attempt to relate the phenomena associated with handedness to the elements of the tracking task. This has implications for both generalizing from previous work and for training should differences be found.

This latter point was tackled by Provins[7] in a later experiment where he studied two simple motor tasks in relation to training and handedness. The tasks employed were: "the accuracy of reproduction of pressure in attempted extension of the elbow joint" and "the speed of oscillation of attempted flexion and extension of the elbow joint". The results of these experiments are as follows:-

1. There was no significant difference between hands on the first task.

2. There was a significant difference between hands on the second task.

3. Training improved the second task but not the first task.

Although Provins does not state this specifically, it would appear from the article that the performance obtained with training on the non-preferred hand could match that of the preferred hand. Provins' conclusion is that "where differences in performance on the two hands occur they may adequately be explained in terms of pre-training or usage".

Summarising the above work therefore, three possible conclusions emerge:

1. In general, there is no marked difference in performance between tracking performance of preferred and non-preferred hands.

2. Tracking tasks employing novel or complex skills may show a difference between preferred and non-preferred hands.

3. This difference is a function of previous training and, ipso facto, training can improve the performance of the non-preferred hand.

This report is an attempt to test the hypotheses outlined above.

2 METHOD

2.1 Subjects

The subjects for this experiment were eight right-handed males between the ages of 18 and 35. Two were craft apprentices and the remaining six were personnel associated with the Psychology Section of the Institute of Aviation Medicine. All were unfamiliar with the Zero-Reader Tracking Task (see below).

2.2 Apparatus

The apparatus employed in this experiment has been described elsewhere (Huddleston[8]). The elements of the apparatus are shown in Figures 1-3. Briefly, the subject's task is compensatory tracking using a position control to null the errors fed independently into the two elements of the zero reader display. The error inputs to both elements is a sine wave and, for this experiment, the values employed were a frequency of 0.1 Hz and an amplitude equal to the total display dimensions. The signals generated are independent and out of phase thus minimizing the predictability of the display for the subject.

The subject sat 0.75 m from the display and his arm was fully supported at a comfortable height allowing complete freedom of movement for the wrist.

2.3 Experimental procedure

The eight subjects were administered the Gedye Handedness Questionnaire (Gedye[9]). All were 'consistent' right-handers and on the basis of the strength of handedness part of the questionnaire were assigned to two matched groups (as far as was possible) by means of their total score on the Four-Question version (see Wilson[10]). These scores are shown in Table 1 of the results section. The treatments received by the two groups differed only in the hand with which they commenced tracking. Subjects 1-4 performed the tracking task using firstly their left (ie, non-preferred hand) whilst subjects 5-8 used their right (preferred) hand. Half-way through the experiment the two groups changed to their other hand.

The experimental procedure was as follows. Each group performed six 3-minute tracking runs with a one minute rest between each run. At the end of the sixth run, a 10-minute rest was taken and a further six 3-minute runs were performed with the other hand. Rest periods were identical to the first period. No practice was allowed before the beginning of the first run. The subjects were told to keep the cross formed by the intersection of the two elements in the target circle (see Fig 1). The control/display relationship was demonstrated to the subject (without error input), namely, that pushing the stick forward moved the horizontal wire upwards and moving the stick to the right moved the vertical wire to the right. Each run began with the display centred and the subject was required to press the button at the top of the stick (which started the recording apparatus) on a command from the experimenter. At the end of each run the apparatus automatically switched off and the 'off' flags came up on the display.

2.4 Scoring

Time-on-target (ToT) scores to the nearest 1/10th sec were obtained for 30-second epochs throughout the experiment. In addition to time-on-target scores for both display elements together in the target circle (V+H condition), separate scores for the two wires independently were also obtained (V and H conditions). One set of counters (see Fig 3) commenced scoring on the 'freezing' of the other counters at the end of the 30-second epoch. These were then reset by the experimenter after recording the scores.

3 RESULTS

Table 1. Handedness Scores for the Two Groups

	SCORE		SCORE
S1	206	S5	183
S2	225	S6	229
S3	247	S7	252
S4	260	S8	263
MEAN:	234.5	MEAN:	231.8

3.1 Analyses

3.1.1 Initially, a Four-Factor Analysis of Variance was performed on the integrated tracking scores over the three minute tracking runs, keeping the scores for the two axes of tracking separate to investigate any possible differences (Huddleston[8]). The following variables were subjected to the analysis SUBJECTS, RUNS, HANDS (ie, left v right) and CONDITIONS (ie, vertical v horizontal). The results are shown in Table 2 below:-

Table 2. Analysis of Variance on Separate V and H Scores

		SS	df	MS	F
Subjects	S	8 675 717.00	7	1 239 388.15	141.11 ***
Runs	R	556 463.00	5	111 292.60	10.16 ***
Hands (L v R)	H	1 113.00	1	1 113.00	- NS
Condition (V v H)	C	633.00	1	633.00	- NS
SR		383 379.03	35	10 953.69	1.25 NS
SH		232 219.03	7	33 174.15	3.78 **
SC		42 999.03	7	6 142.72	- NS
RH		77 171.00	5	15 434.20	1.76 NS
RC		59 811.00	5	11 962.20	1.36 NS
HC		17 599.00	1	17 599.00	2.00 NS
SRH		406 312.97	35	11 608.94	1.32 NS
SRC		286 100.97	35	8 174.31	- NS
SHC		43 208.97	7	6 172.71	- NS
RHC		28 308.99	5	5 661.80	- NS
RESIDUAL		307 405.04	35	8 783.00	
TOTAL		11 118 441.00	191		

*** = significant at 0.001 level
** = significant at 0.01 level
* = significant at 0.05 level
NS = non-significant

Since no differences between the horizontal and vertical axes were present (the Conditions variable and all interactions in which this variable is involved being insignificant) all future analyses were performed on the compounded (V + H, scores as recorded by the zero-reader recorder.

3.1.2 A Three-Factor Analysis of Variance was then performed on this data in which the following variables were investigated: SUBJECTS, HANDS and RUNS. The results are shown in Table 3 below:-

Table 3. Analysis of Variance on (V + H) Scores (i)

	SS	df	MS	F
Subjects	9 887 300.00	7	1 412 500.00	138.22 ***
Hands	226.50	1	226.50	- NS
Runs	589 900.00	5	117 980.00	8.28 ***
H x R	55 271.00	5	11 054.00	1.08 NS
S x R	498 850.00	35	14 253.00	1.39 NS
S x H	180 580.00	7	25 798.00	2.52 *
RESIDUAL	357 670.00	35	10 219.00	
TOTAL	11,569 797.50	95		

3.1.3 A further Three-Factor Analysis of Variance of the same data analysed the order effect. Thus, the three variables were:- SUBJECTS, ORDER and RUNS. These results are shown in Table 4:-

Table 4. Analysis of Variance on (V + H) Scores (ii)

	SS	df	MS	F
Subjects	9 887 300.00	7	1 412 500.00	171.18 ***
Order	150 660.00	1	150 660.00	18.26 ***
Runs	589 900.00	5	117 980.00	8.28 ***
OR	124 130.00	5	24 825.00	3.01 *
SR	498 850.00	35	14 253.00	1.73 *
SO	30 155.00	7	4 307.80	- NS
RESIDUAL	288 810.00	35	8 251.70	
TOTAL	11 569 805.00			

3.1.4 Combining the above analyses produces Table 5 which is effectively a Four-Factor Analysis of Variance in which second-order interactions and above are compounded in the residual and the first-order reaction of Hands x Order is omitted.

Table 5. Combined (V + H) Results from Tables 3 and 4

	SS	df	MS	F
Subjects	9 887 300.00	7	1 412 500.00	589.29 ***
Hands	226.00	1	226.00	- NS
Runs	589 900.00	5	117 980.00	8.28 ***
Order	150 660.00	1	150 660.00	34.97 ***
S x H	180 580.00	7	25 798.00	10.76 ***
S x R	498 850.00	35	14 253.00	5.95
S x O	30 155.00	7	4 307.80	1.80
H x R	55 271.00	5	11 054.00	4.61
R x O	124 130.00	5	24 825.00	10.36
RESIDUAL	52 733.00	22	2 396.95	
TOTAL	11 569 805.00	95		

3.1.5 A series of non-parametric analyses were then performed on the data shown in Appendix A which gives the mean percentage time on target scores per 3-minute run. These results will be examined as they occur in the Discussion of Results Section. The scores are also shown graphically in Fig.4.

3.1.6 A more detailed examination of the learning which occurred in this experiment in terms of the phenomena of reminiscence and bilateral reminiscence requires Figure 4 to be re-drawn in terms of smaller time epochs (namely 30 secs) with the abscissca showing elapsed time. These are shown in Figs.5 and 6.

3.1.7 Handedness scores as measured both by the 5-Question and 4-Question version of the Gedye handedness questionnaire were correlated with overall tracking scores using a Pearson product-moment correlation. These are shown in the tables below (Tables 6 and 7).

Table 6. Handedness and Tracking Scores for the Eight Subjects

SUBJECT No.	Mean ToT for Right Hand	Mean ToT for Left Hand	Mean Overall ToT	Handedness (5-Question)	Handedness (4-Question)
1	48.46	43.43	45.95	209	206
2	64.18	61.79	62.99	232	225
3	73.97	70.43	72.20	248	247
4	80.85	73.86	77.36	285	260
5	56.31	63.68	60.00	194	183
6	87.24	90.00	88.62	257	229
7	86.38	88.04	87.21	263	252
8	32.31	37.45	34.88	345	263

Table 7. Correlations of Handedness and Tracking Scores

	Mean ToT for Right Hand	Mean ToT for Left Hand	Mean Overall ToT
5-Question	- 0.154	- 0.139	- 0.148
4-Question	+ 0.202	+ 0.135	+ 0.171

3.2 Discussion of results

With regard to the main hypothesis under test, namely, whether there is a difference in performance between preferred and non-preferred hands, the results of the Analyses of Variance performed on the data are clear. There is no significant difference between the hands variable on either the analysis performed on V and H separately (Table 2) or the combined V+H scores (Tables 3 and 5). The only significant interaction involving the Hands variable is the S x H interaction (Table 2; $F = 3.78$, $p < 0.01$: Table 3; $F = 2.52$, $p < 0.05$: Table 5; $F = 10.76$, $p < 0.001$). As will be demonstrated later, this can be accounted for in terms of the order in which the subjects performed the two periods of tracking.

Table 5 shows the other significant main variables from this experiment. Based on the V + H scores (since no difference between the two elements has been demonstrated in Table 2) the two significant variables are Runs ($F = 8.28$ $p < 0.001$) and Order ($F = 34.97$, $p < 0.001$). These effects are best illustrated by reference to Fig.4 which shows mean percentage Time-on-Target scores for the two groups of subjects (1-4 and 5-8) plotted against run number. The data from which this graph is plotted are shown in Appendix A.

A number of non-parametric analyses were then performed on the data shown in this Table to investigate the Hand and Order effects and their interactions.

Mann-Whitney U-tests were used for comparisons between scores obtained from different subjects whilst Wilcoxon Matched Pairs Tests were used for tests involving the same subjects. All significance levels quoted are for two-tailed tests.

There was no significant difference in performance between the two groups in the first period (ie six runs) of tracking ($U = 369.5$, $z = 1.68$ ns) or in the second period ($U = 344.0$, $z = 1.15$ ns). Since the two groups were using different hands within each period, this further confirms the findings of the parametric analyses referred to above. Comparing the two groups on total tracking ability, (ie scores for periods I and II together) however, shows that subjects 5-8 are slightly superior in their tracking ability to subjects 1-4 (Wilcoxon; T = 12, N = 12, $p < 0.05$ level). This difference is only marginal as reference to Fig 4 shows; in fact both groups finish Period I at approximately the same performance level and commence Period II at the same level. This finding will be examined further when the learning effects are considered. This difference in performance between the two groups does not significantly alter any of the previous or subsequent conclusions to be drawn as significance levels of $p < 0.02$ or less will be used for the main findings.

Performance in the second period of tracking is significantly higher than in the first period (Wilcoxon; T = 0, N = 8, $p < 0.005$) - this confirms the parametric finding of Table 5. Keeping the hands variable constant and comparing subjects 1-4 performance in Period I with subjects 5-8 in Period II shows no significant difference for the Left (non-preferred) Hand (Mann-Whitney U; U = 368, z = 1.65 ns). Similarly, for the Right hand, subjects 5-8 in Period I are not significantly different from subjects 1-4 in period II. (Mann-Whitney U; U = 314.5, z = 0.546 ns).

Neglecting the hand variable, however, and comparing performance between Period I and Period II for subjects 1-4 and subjects 5-8 separately, significant differences emerge. For subjects 1-4, performance on Period II was significantly better than Period I (Wilcoxon; T = 60.5, N = 24, $p < 0.01$) likewise for subjects 5-8 although at a lower level of significance (Wilcoxon; T = 66, N = 24, $p < 0.02$). This differential level of significance probably reflects the somewhat lower initial tracking scores of subjects 1-4 in Runs 1 and 2 of Period I. This is further discussed in the section on Learning Phenomena (below).

With regard to the significant subjects x hands interaction mentioned before this is completely accounted for by the order effect. Subjects 1-4 score higher on their right hand than their left since they performed the latter first, whilst subjects 5-8 perform better on their left hand than their right for the same reason.

3.3 Learning phenomena

That the tracking scores for Period II are significantly higher than those Period I indicates that learning has taken place. The learning trends are best illustrated in Figs 5 and 6 which give a detailed description of the time course of performance with respect to integrated time-on-target scores over 30-second epochs. It should be noted that these learning curves within each period do not comply with the theoretical expectations of reminiscence effects (an initial improvement in post-rest performance over that of pre-rest performance). For a detailed description of these phenomena see Ammons[11] and Eysenck[12]. (The special case of bilateral reminiscence ie performance at the beginning of Period II compared with that of the end of Period I when a different hand is employed will be dealt with in the Discussion section.) Why reminiscence effects are absent is not clear, although the small number of subjects involved is the most probable explanation. This, again will be dealt with further in the next section.

Regression lines were fitted to the four sets of scores in Fig.4. Only one of these however was significant (Subjects 1-4, Left Hand; $F = 110.54$ $p < 0.001$). The remaining three sets of scores cannot therefore best be described in terms of a straight line. Nevertheless, 'best-fit' straight lines were obtained for all four sets of data and their slopes compared. Within subjects, Period I was significantly different from Period II for subjects 1-4 ($t = 6.803$ $p < 0.01$) but not for subjects 5-8.

Within Periods, there was a marginally significant difference between the slopes of the two groups in Period II ($t = 3.153$, $p < 0.05$) but not for Period I. Inspection of Fig 4 would suggest that a probable explanation of the significant difference in Period II is that, whilst the performance of subjects 1-4 (the marginally poorer trackers) had plateaued, subjects 5-8 were still improving. Bearing in mind that the significance level is below that agreed to be useful and that the regression lines are not in themselves significant, this finding will not be discussed further.

That there is no significant difference between the two groups in terms of the performance slopes in Period I is surprising - considering the difference in initial performance between the two groups. Again this must be accounted for in terms of the non-significant regression of one of the 'best-fit' lines (subjects 5-8).

3.4 Relationship between tracking performance and handedness scores

Table 6 shows Mean Time-on-Target scores for Right hand, Left hand and total tracking ability separately for the eight subjects with their handedness scores on both the 5-Question and 4-Question version.

Pearson product-moment correlations were performed using both sets of handedness scores separately with all of the tracking scores and the results are shown in Table 7. None of the correlations are significant, but it is of interest to note that the correlations using the 5-Question version are all negative and those using the 4-Question version are all positive. The expected direction of correlation is positive and the 5-Question of the Gedye Handedness Questionnaire has been shown (Wilson[10]) to be less reliable than the 4-Question version. However, since the correlations are not significant no real conclusions can be drawn.

4 DISCUSSION

The results of this experiment confirm Hypothesis 1 as indicated in the Introduction; there is no difference between performance with the preferred and non-preferred hands. Hypothesis 2 is negated if the zero-reader tracking task is defined as one involving novel or complex skills. Certainly the task itself was a novel one to all the subjects employed in this experiment, but how far it involved novel skills is debateable. Only a micro-analysis of the task into skills of the Provins kind can really answer this question. Some supporting evidence for this hypothesis can be gleaned from a closer inspection of the first two runs of this experiment. A Mann-Whitney U Test ($U = 30$, $p < 0.01$ one-tailed) shows that the 'better' trackers (ie S's 5-8) are superior to S's 1-4 on their tracking scores for these first two runs at a higher level of significance than the overall level. In other words, it could be argued that <u>initially</u> performance with the non-preferred hand is slightly worse than that with the preferred hand. By the end of the first period, however, the two groups have identical scores. This is in direct conflict with Ross's results with mirror-tracing where he showed that initially the non-dominant hand was superior, but is soon overtaken by that of the dominant (see Introduction). It should be stressed though that in addition to the very differing nature of the tasks employed, the evidence presented here with regard to these initial effects is far from rigorous.

The verification of Hypothesis 3 was attempted indirectly. The strength of handedness scores obtained for each subject were the only attempts made to measure previous training. Obviously it is a very crude measure of prior ability with the non-preferred hand and, having shown no overall difference between the preferred and non-preferred hands on tracking ability, it is not surprising that the handedness scores did not significantly correlate with either performance on the dominant and non-dominant hands or overall tracking ability.

The problems associated with reminiscence effects are enormous. Many variables effect the phenomenon, the two most important being length of pre-rest trial and length of rest; arising out of these is a third, namely, whether the practice is massed or spaced.

Within periods the situation is far simpler than between periods. Each 'unit' for investigating the phenomenon is a 3-minute pre-rest trial (massed), a 1-minute rest and a 3-minute post-rest trial (massed). Under these conditions, reminiscence effects are to be expected although not very great (Chap. 3 in Eysenck[12], Ammons[13]). That they have not occurred in this experiment has been mentioned before (see previous section) and is accounted for in terms of the small number of subjects employed.

Of more interest to the present experiment is the problem of bilateral reminiscence where pre and post rest trials are performed with different hands. In general the findings are the same as for unilateral reminiscence (Irion and Gustafson[14], Rockway[15], Spatz[16]). In the present experiment the pre-rest performance was spaced (6 x 3 minute trials with 5 interpolated 1-minute rest periods) and the rest period was ten minutes. Rockway showed that performance with the non-preferred hand was an increasing function of the amount of performance with the preferred hand and the length of the rest period. Both were much shorter than the values employed here (maximum pre-rest performance was 5 minutes and maximum rest length was 5 minutes) but the practice was massed. Eysenck[17] has clearly demonstrated the superiority of massed practice in producing reminiscence phenomena and this, it is felt, accounts for the fact that it has not occurred here. The lower level of performance post-rest is most probably due to a warm-up phenomenon - the length of the rest period being sufficient to produce a high decrement due to warm-up (see Ammons[13] and Wilson[18]).

5 CONCLUSIONS

With regard to the main hypothesis under test in this experiment the evidence is fairly clear. There was no difference in performance between preferred and non-preferred hands on the tracking task employed. How far this can be generalised obviously depends on the situation involved, but it would appear that for tasks which fall under the general heading of 'tracking' that there is no real difference between the two hands and that any initial lower performance of the non-preferred hand is very quickly brought up to the standard of the preferred hand.

Appendix A

PERCENTAGE TIME-ON-TARGET SCORES PER THREE MINUTE RUNS

LEFT FIRST								RIGHT SECOND							
S	1	2	3	4	5	6	MEAN	S	1	2	3	4	5	6	MEAN
1	30.33	37.33	32.11	49.89	47.56	63.33	43.43	1	49.16	50.11	40.16	48.11	56.61	46.61	48.46
2	47.94	61.72	60.44	59.72	73.89	67.05	61.79	2	56.61	69.55	62.22	59.38	66.94	70.38	64.18
3	57.55	63.05	78.49	66.88	74.55	80.05	70.43	3	70.49	69.27	80.99	74.94	76.88	71.22	73.97
4	70.61	59.72	78.27	77.49	70.72	86.32	73.86	4	84.82	77.44	78.44	78.66	79.83	85.88	80.85
$\bar{m}$	51.61	55.46	62.33	63.50	66.68	74.19	62.38	$\bar{m}$	65.27	66.59	65.45	65.27	70.07	68.52	66.86

RIGHT FIRST								LEFT SECOND							
S	1	2	3	4	5	6	MEAN	S	1	2	3	4	5	6	MEAN
5	43.33	63.27	42.83	64.66	49.50	74.27	56.31	5	66.99	66.10	56.16	62.55	60.77	69.49	63.68
6	84.77	80.38	84.55	90.99	89.44	93.32	87.24	6	87.44	87.49	90.38	92.44	92.60	89.66	90.00
7	79.83	87.71	82.88	83.82	91.49	92.55	86.38	7	86.27	85.77	81.33	91.27	90.60	92.99	88.04
8	22.44	33.55	33.50	30.33	31.55	42.50	32.31	8	21.11	34.66	29.33	42.44	43.66	53.49	37.45
$\bar{m}$	57.59	66.23	60.94	67.45	65.50	75.66	65.56	$\bar{m}$	65.45	68.51	64.30	72.18	71.91	76.41	69.79

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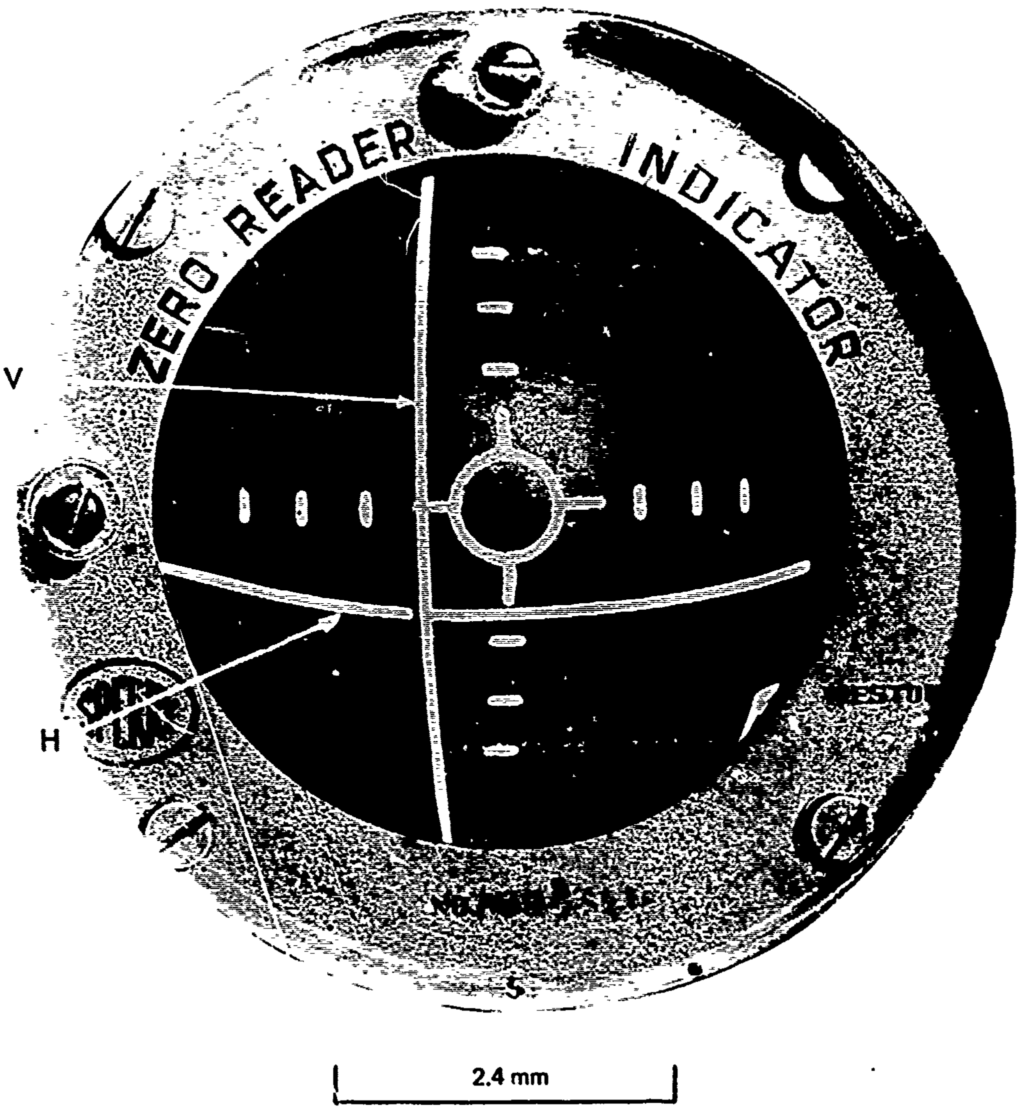
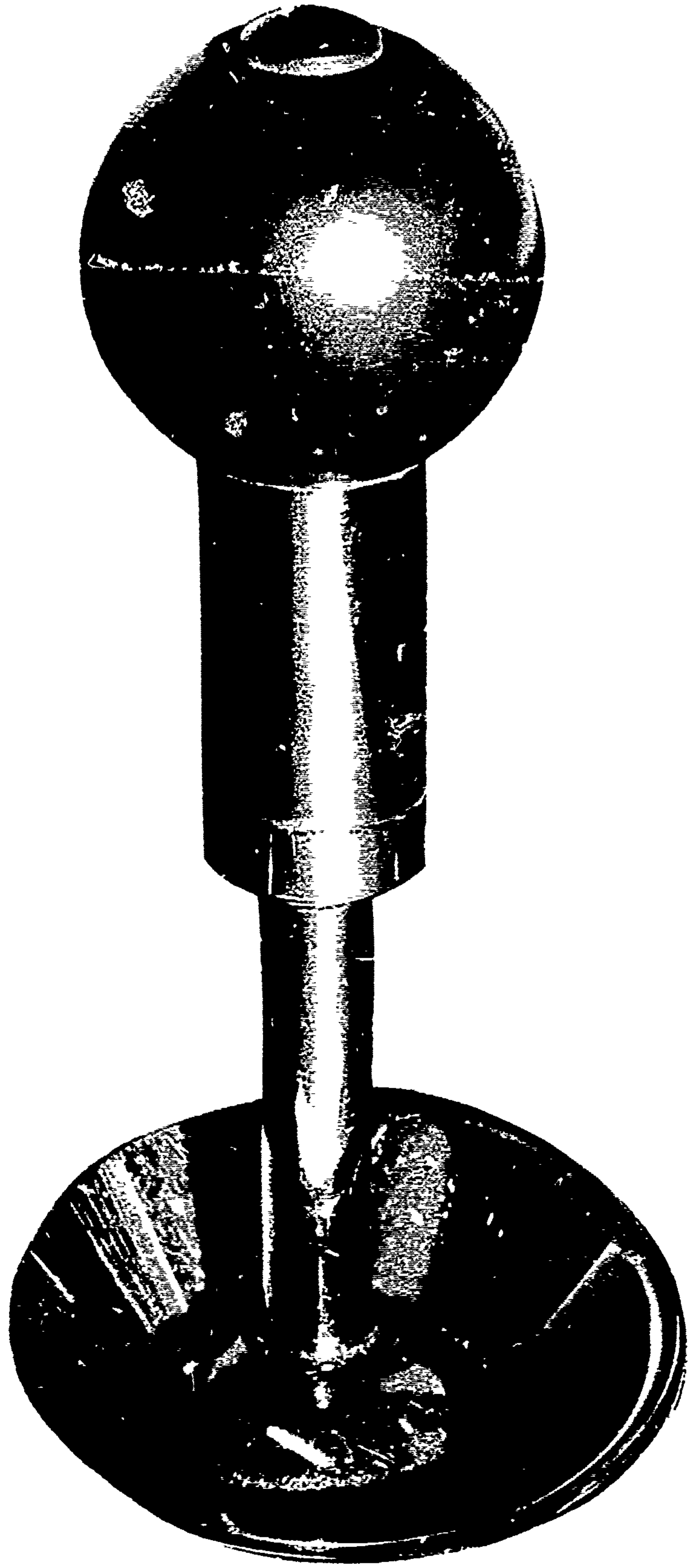
16	K. C. Spatz	An analysis of bilateral and unilateral reminiscence. Dissertation Abstracts. 27, 5B 1646 (1966) (Abstract only).
17	H. J. Eysenck	'Warm-up' in pursuit-rotor learning as a function of the extinction of conditioned inhibition. Acta Psychol. 12, 349-370 (1956)
18	R. V. Wilson	The effect of rest on rotary pursuit performance. (Unpublished) (1965).



Zero reader indicator

Fig.1 Zero-reader display

TR 72117 C9220



2.4 mm

Fig.2 Joystick control

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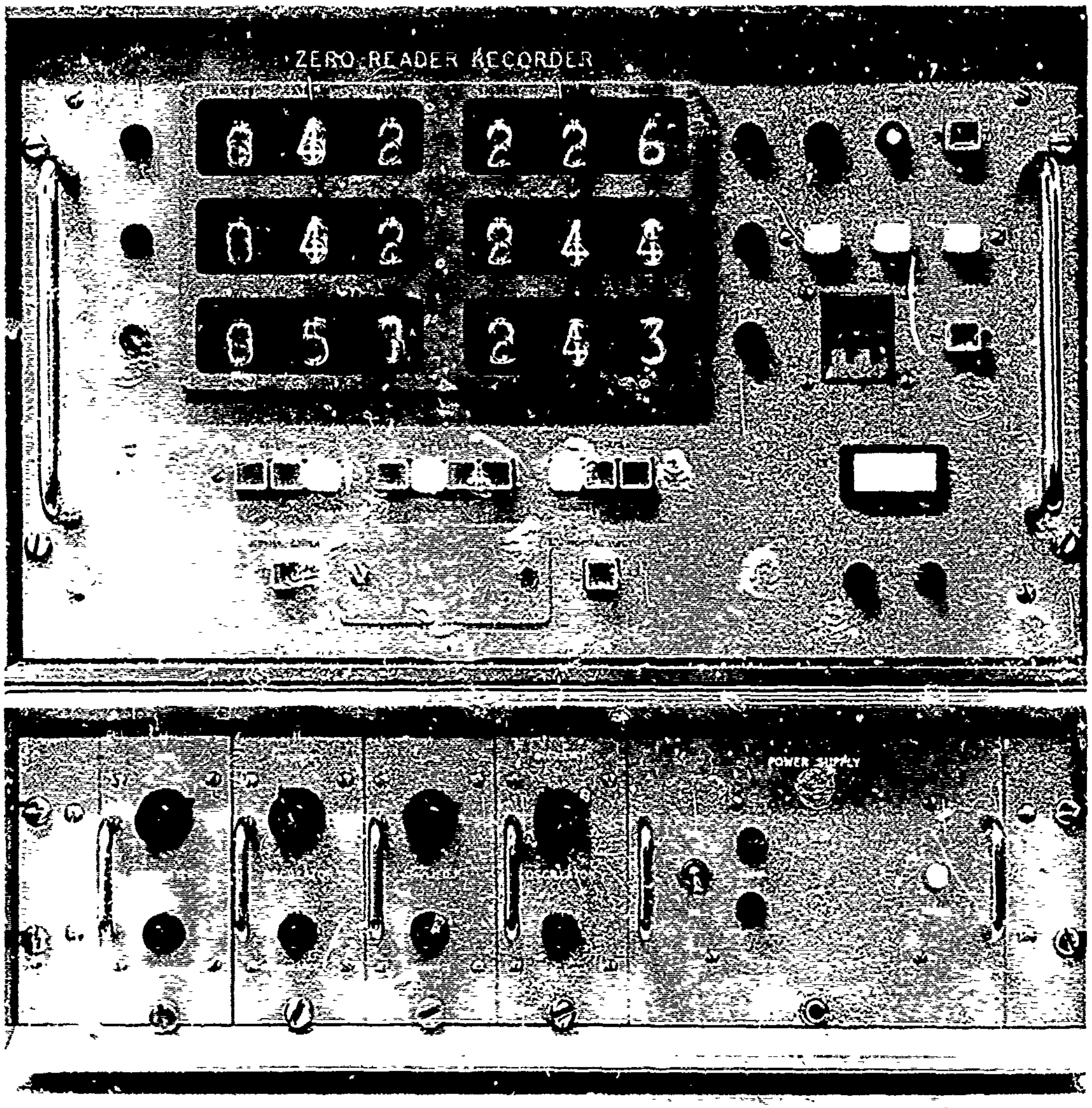

Fig.3 Zero-reader recorder and error generators

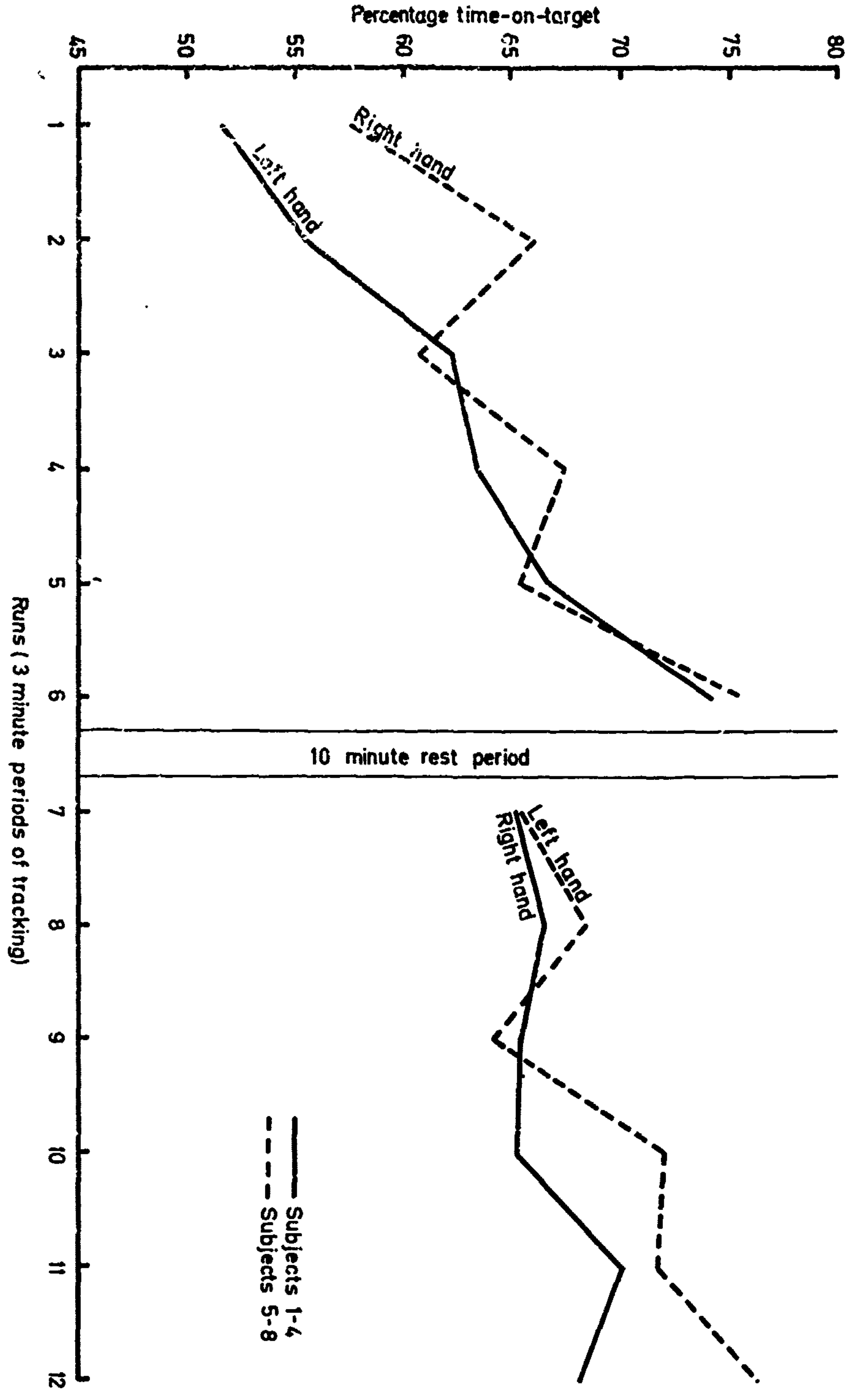

Fig.4 **Graph of mean percentage time-on-target scores against run number for right and left hands**

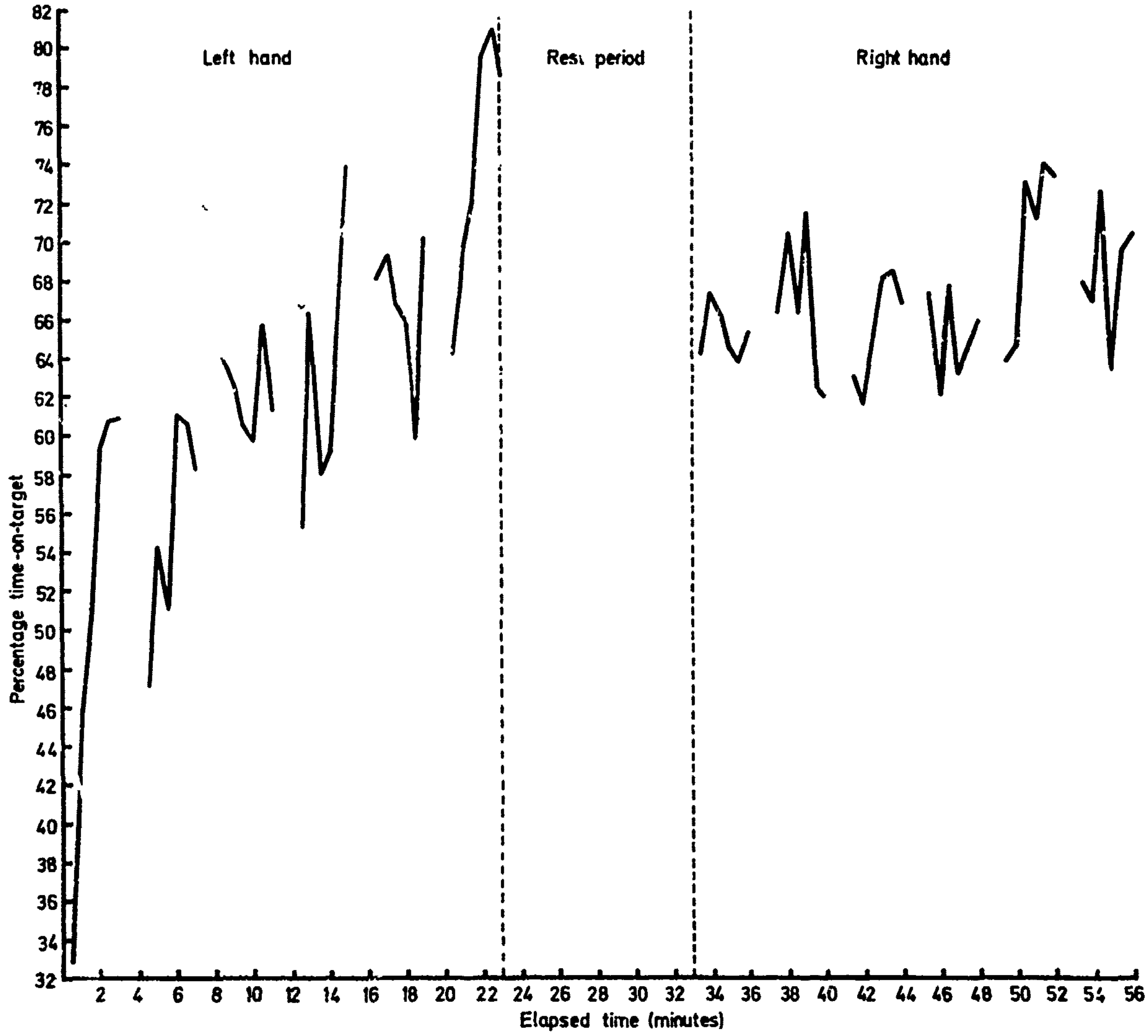

Fig.5 Graph of percentage time-on-target against elapsed time for subjects 1-4

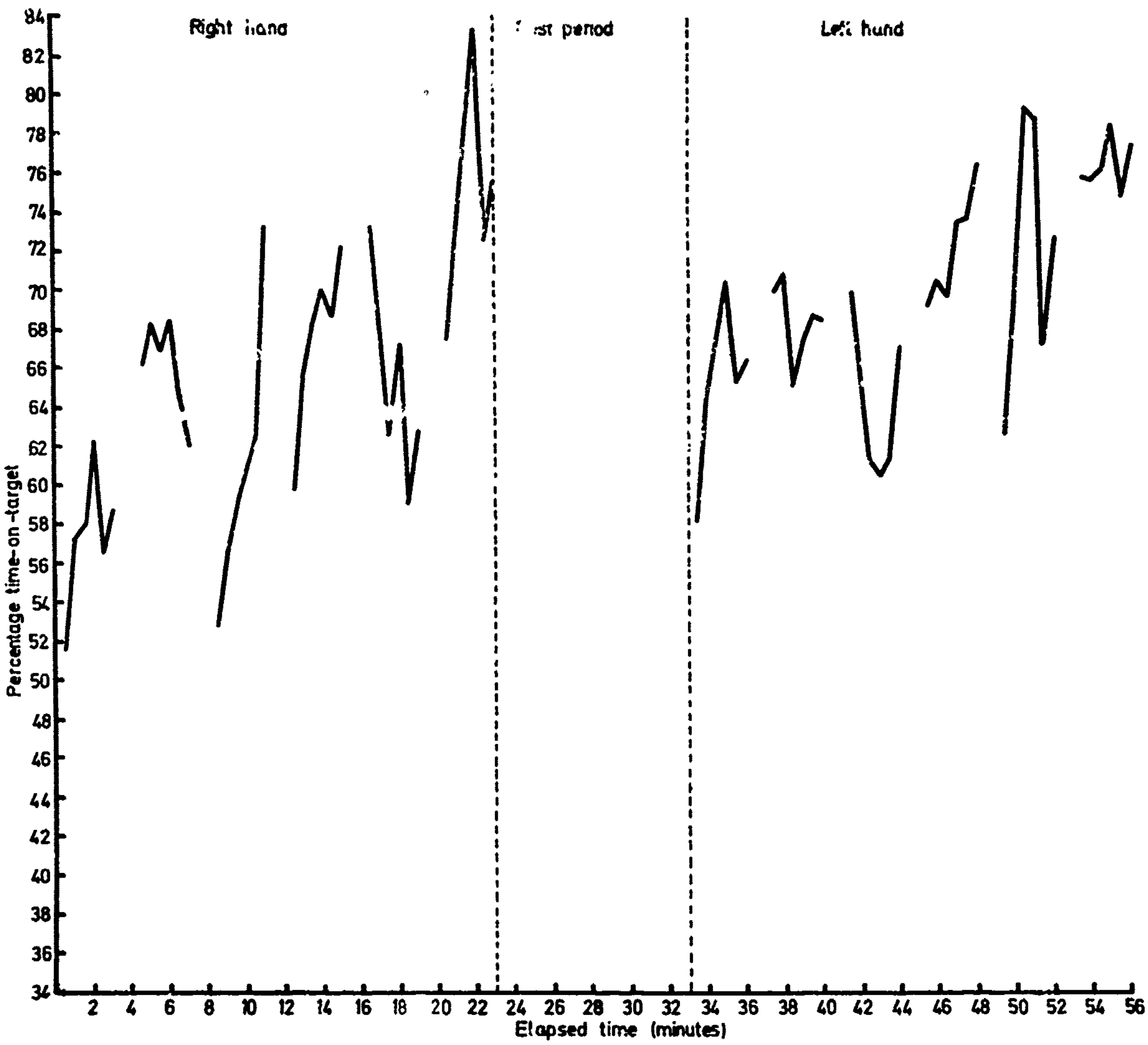

Fig.6 Graph of percentage time-on-target against elapsed time for subjects 5-8

TR 72117 C9228